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GOVERNMENT REVIEW OF THE COUNTDOWN COMPANIES 1993 AND 1994 ACID GAS EMISSION AUDITS

(Final Report)

OCTOBER 1996

Ontario

Ministry of
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and Energy

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(Final Report)

Report prepared by:

Science and Technology Branch
and
Northern Ontario Region
Ontario Ministry of Environment and Energy

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EXECUTIVE SUMMARY

This report summarizes the results of environmental compliance audits of the four major acid rain emitters of sulphur dioxide (SO_2) and nitric oxide (NO) in the Province of Ontario for 1993 and 1994. These auditing programs were applied to three metallurgical companies; namely, INCO Limited, Falconbridge Limited and Algoma Steel Inc. (Wawa Operations), and to Ontario Hydro's fossil-fuelled generating plants to ensure that their 1994 regulated emission levels were being met. These four major emitters were regulated under Ontario's Countdown Acid Rain Program Regulations and by Director's Orders under Section 18, Environmental Protection Act R.S.O. 1990.

INCO:

The auditor verified that INCO Limited's SO_2 emissions of 358 kilotonnes (kt) for 1993 and 162 kt for 1994 were calculated using the mass balance procedures approved by the Ministry of Environment and Energy (MOEE). Minor deviation and observations from the sulphur mass balance manual did not significantly affect the reported emissions. Recommendations were also provided to improve the procedures in order to increase the reliability and accuracy of the emissions. The uncertainty in the estimated annual SO_2 emissions was ±2.0% for 1993 and ±4.5% for 1994. In 1994, INCO Limited was 39% below the regulated SO_2 annual emission limit of 265 kt.

Falconbridge:

Falconbridge Limited reported SO_2 emissions of 57 kt for 1993 and 54 kt for 1994 from their smelter operation in Falconbridge. There were no major deviations from the procedures manual noted by the auditor. The overall uncertainty of the reported annual SO_2 emissions was ±4.9% for 1993 and ±4.7% for 1994. In 1994, Falconbridge Limited was 46% below the regulated SO_2 annual emission limit of 100 kt.

Algoma (Wawa):

Algoma Steel Inc.(Wawa operations) reported SO_2 emissions of 50.4 kt for 1993 and 35.5 kt for 1994 from their sinter plant operations. Their emissions uncertainty was determined to be

±1.6% for 1993 and ±1.9% for 1994. There were no major deviations from the procedures manual noted by the auditor. In 1994, Algoma Steel Inc. was 72% below the regulated SO_2 emission limit of 125 kt.

Ontario Hydro:

Audits of Ontario Hydro's fossil fuel generating facilities confirmed that the reported combined annual SO_2 and acid gas (SO_2 + NO) emissions for 1993 were 96.7 kt and 130.0 kt, with uncertainties of ±4.2% and ±3.3%, respectively. Ontario Hydro reported SO_2 and acid gas emissions of 106 kt and 135.5 kt for 1994 with an uncertainty of ±3.0% and ±2.5%, respectively. No significant errors affecting the quantity and accuracy of emissions were noted by the auditor. In 1994, Ontario Hydro was 39% below the SO_2 emission and 37% below the acid gas emissions (SO_2 + NO) regulated limits of 175 kt and 215 kt, respectively.

1 INTRODUCTION

An acid gas emissions verification program was implemented in 1990, as part of the Countdown Acid Rain Program to ensure that the 1994 regulated emission levels were being met. This verification program was applied to four regulated companies; namely, the metallurgical companies INCO Limited, Falconbridge Limited and Algoma Steel Inc. (Wawa Operations), and Ontario Hydro's fossil fuelled generating plants (Reg. 660/85, 661/85 and 663/85 and 355/90 (formerly Ont. Reg. 281/87). These four emitters were further directed to perform annual procedural emission audits under Section 18(formerly Section 17) Director's Orders of the Environmental Protection Act, R.S.O. 1990.

The Countdown Acid Rain program limits the acid gas emissions for the four emitters, according to the following schedule:

Ontario's Countdown Acid Rain Program

Annual Acid Gas Emission Limits*
in Kilotonnes

COMPANY	1986	1990	1994	(1994 & beyond)
INCO Limited	685	685	265	
Falconbridge Ltd.	154	154	100	
Algoma Steel	180	180	125	
Ontario Hydro	370	240	175	
	430	280	215	(SO_2 plus NO)

* For SO_2 except where noted otherwise.

The Director's Orders, issued under Section 18 of the Environmental Protection Act R.S.O. 1990, required the emitters to prepare and submit Sulphur Mass Balance (SMB) Procedures Manuals, and determine the overall uncertainty of their respective annual emissions. In addition, the emitters were required to engage an independent auditor to develop an Audit Protocol Manual and conduct procedural audits of the reported emissions. The auditors were required to evaluate and comment on the SMB procedures and, in the case of Ontario Hydro, determine the nitric oxide (NO) vs. load curves to estimate NO emissions as required by their respective regulations. Overall, the auditors were to confirm that the reported emissions were verifiable, accurate and reliable.

The background for the emission verification program is detailed in earlier reports entitled "Government Review of the Countdown Companies 1991 Acid Gas Emissions Audits[1]" and "Government Review of the Countdown Companies 1992 Acid Gas Emissions Audits[2]". These reports summarize the findings of the 1991 and 1992 acid gas emissions audits.

2.0 DIRECTORS' ORDER REQUIREMENTS

All four emitters were determined to be in compliance with the various requirements of their individual Orders. The four emitters reported annual acid gas emissions based on the SMB method and Ontario Hydro also used the NO vs. load curves (NOx emission factors) to estimate NO emissions. Audits were conducted according to the approved audit protocol manuals to determine the degree of compliance with the SMB procedures. The audits comprised random verification of: sampling, weighing and assaying methods, assaying and weighing results, and calculations used to determine emission quantities. Statistical estimates of the emission uncertainty were also determined, reviewed and validated.

Various developments, since the Orders were issued in June and July of 1990, are summarized as follows:

2.1 INCO Limited

INCO Limited was granted an extension until the end of 1994 to complete a study on the feasibility of using continuous emission monitoring (CEM) to report annual SO_2 emission quantities. This CEM study was undertaken after the new smelter process changes were completed (November 1993) and reached a steady-state operation. The results of this study are being evaluated.

2.2 Falconbridge Limited

Falconbridge Limited was also required to study the feasibility of using CEM to report annual SO_2 emissions quantities from its smelter operation. The final study report, prepared by Hatch Associates Ltd., was submitted in December 1993. The report indicated that CEM was difficult to justify financially and that SMB provided a reliable and cost-effective method for estimating SO_2 emissions.

2.3 Algoma Steel Inc. (Wawa)

Algoma's Wawa sinter plant is in compliance with all the requirements of the Director's Order. The SO_2 emissions are being reduced as the company continues to increase the processing of recyclable oxides/revert materials. These materials contain less sulphur than the iron ore mined in the Wawa area.

2.4 Ontario Hydro

The Order was amended in February 1992 to provide additional time to solve technical problems with newly installed Continuous Flue Gas Monitoring (FGM) systems. All of Ontario Hydro's FGM systems on the operating boilers have been verified for calibration drift (CD) tests and relative accuracy test audit (RATA), and all systems have met CD and ≤ 20% relative accuracy (RA) requirements. Ontario Hydro has completed two separate studies to show:

(i) the equivalency of FGM systems to CERM (in-stack monitoring) systems and;

(ii) the accuracy of SO_2 and NO emissions measurements using FGMs compared to SMB and NO emission factors determinations.

(As a result of these studies the Ministry has accepted Ontario Hydro's continuous emission monitoring systems and the Director's Order was amended accordingly on June 1, 1996)

3.0 AUDIT FINDINGS FOR 1993 AND 1994

The auditors have confirmed that the reported emissions for 1993 and 1994 from the metallurgical companies and Ontario Hydro were reliable, accurate and verifiable. The auditors also confirmed that the emissions were well within the limits as required by their respective Ontario Regulations (Reg. 660/85, 661/85 and 663/85 and 355/90 (formerly Ont. Reg. 281/87)).

The following tables summarize the 1993 and 1994 SO_2 and acid gas emission levels, and their associated accuracy.

1993 EMISSIONS LEVELS

Sources	Legal Limit Requirements 1993 (kt)	Emission Levels 1993 (kt)	Percent Below Limit	Accuracy ± %
INCO Limited (SO_2)	685	358.0	48	2.0
Falconbridge Limited (SO_2)	154	57.0	63	4.9
Algoma Steel Inc.(Wawa)(SO_2)	180	50.4	72	1.6
Ontario Hydro (SO_2)	240	96.7	60	4.2
(SO_2+NO)	280	130.0	54	3.3

1994 EMISSIONS LEVELS

Sources	Legal Limit Requirements 1994 (Kt)	Emission Levels 1994 (Kt)	Percent Below Limit	Accuracy ± %
INCO Limited (SO_2)	265	162.0	39	4.5
Falconbridge Limited (SO_2)	100	54.0	46	4.7
Algoma Steel Inc.(Wawa)(SO_2)	125	35.5	72	1.9
Ontario Hydro (SO_2)	175	106.5	39	3.0
(SO_2+NO)	215	135.5	37	2.5

3.1 INCO Limited

The auditor, Price Waterhouse (2)&(3), confirmed that the 1993 and 1994 SO_2 emissions from the Copper Cliff Smelter and Refinery operations were 358 kt and 162 kt, respectively. These emissions were 48% and 39% below the limit of 685 kt for 1993 and 265 kt for 1994.

The auditor noted only minor deviations from the SMB procedures for SO_2 emissions estimating method. These deviations have been corrected and the improvements recommended by the auditor have been implemented. Further, the company is fine-tuning the method used for determining the overall uncertainty of the reported annual SO_2 emissions.

Highlights of the Auditor's Report:

The auditor confirmed that the reported SO_2 emissions were based on materials sampling, weighing, assaying and calculating methods described in the Procedures Manual. The uncertainty of the SO_2 emissions in 1993 was determined to be ±2.0%. The auditor revised the uncertainty in 1994 to ±4.5%, resulting from the copper and nickel bulk smelting process changes in November of 1993. The uncertainty includes estimated weighing and assaying errors but does not include sampling errors, sample preparation errors and bias errors.

Some of the most significant deviations are highlighted as follows:

- not running certified reference samples for quality control purposes or to the original frequency for the bulk nickel/copper/cobalt concentrate, dump slag loss scrap and mattes determinations and acid assays as outlined in the procedures manual
- not documenting that the unaccounted loss provision is now applied to the mines at 1.3% of the dry tons ore produced and not as 80% to the mills and 20% to the smelter as done in the past and that the bulk concentrate weight determination uses the inter-smelter adjustment.
- not undertaking a rigorous and representative sampling program for liquid SO_2 and sulphuric acid,
- not consistently collecting samples at proper sampling frequency, preparation and compositing of matte materials according to production tonnages.

3.2 Falconbridge Limited

The auditor, Hatch Associates Ltd.(4) & (5), verified that the reported 1993 and 1994 SO_2 emissions were 57 kt and 54 kt, with an overall uncertainty of ±4.9% and ±4.7%, at 95% confidence level, respectively. Several minor deviations of the SMB procedures were noted. A number of recommendations were also provided to address these deviations.

Highlights of the Auditor's Report:

The Auditor confirmed that the SO_2 emissions of 57 kt and 54 kt reported by Falconbridge Limited for 1993 and 1994, were based on the procedures described in the procedures manual. These emission levels were 63% less than the 1993 limit of 154 kt and 46% below the 1994 regulated limit of 100 kt. The uncertainty of the emission for 1993 and 1994 was determined to be ±4.9% and ±4.7%, respectively.

The recommendations to address the deviations from the SMB procedures are summarized as follows:

- improve the roaster feed determination by developing procedures to monitor the calibration of the instruments used in the automatic tank drop test; provide criteria for accepting the pump factors; modify the average hourly roaster feed rate calculations to properly account for periods when roaster feed pumps are recycling the feed tank contents; record results on the hourly roaster and furnace summaries to a significant number of digits; record production day, slurry cylinder weights and cylinder volumes and dry solid density data to ensure these values are used by the computer; and modify procedures to reflect automatic calculations of the hourly roaster feed.

- develop procedures to calibrate the coke belt scale on furnace #2; modify computer programming for calculating an hourly average coke addition; prepare coke sample; transfer coke assays; reduce coke sampling time and specify that 3 coke belt cuts must be taken.

- keep records of remedial actions taken for matte assays when control points are outside control limits, ensure the matte weighing scale prints the proper date, and is serviced and calibrated at least every four months, and update the matte rolling/homogenising method used.

- clarify the sulphuric acid sampling techniques for daily sampling, locations and frequencies; acid plant tanker truck weighing procedures, re-certify the mass flow meter and formalize a procedure for checking and calibrating or modify the weighing procedure completely.

3.3 Algoma Steel Inc.

The auditors, Rowswell and Associates Engineers Ltd.(6) and

DNE Knight Piésold Consulting Engineers (7), confirmed that the company's reported 1993 and 1994 SO_2 emissions of 50.4 kt and 35 kt were accurate within ±1.6 and ±1.9 of the calculated value respectively, at the 95% confidence level. These emission levels were 72% less than the 1993 set limit of 180 kt and 72% below the 1994 regulated set limit of 125 kt. The improvements recommended by the auditors will be carried out before the next audit.

Highlights of the Auditor's Report:

The auditors confirmed that no major deviations from the Procedures Manual in 1993 and 1994, respectively, were noted.

The company continues to develop a Quality Assurance and Quality Control(QA/QC) program for assaying sulphur in the blended ore, oxides and sinter using LECO and X-ray spectrometer methods. DNE Knight Piésold recommends the replacement of the yearly blended ore composite sample with a statistical analysis of the data provided from the on-going QA/QC program.

The auditors noted that the reliability and accuracy of estimated SO_2 emissions can be improved by:

i) maintaining the tracking alignment of the main ore, oxide and limestone feed belt (T-14) and associated weigh scale; by regularly inspecting the scale mechanism (T-14 and T-8) and cleaning them to remove debris material;

ii) maintaining and regularly calibrating scales;

iii) not accounting separately for fines, subgrade material, blast furnace oxides and other oxides since their lower sulphur content is inherently accounted for as confirmed by DNE Knight Piésold.

3.4 ONTARIO HYDRO

The 1993 and 1994 audits conducted by Angus Environmental Ltd. (8) & (9) (AEL) confirmed that the reported annual SO_2 and acid gas emissions of 96.7 kt and 130 kt for 1993 and 106 kt and 135.5 kt for 1994 were accurate and in compliance with Ontario Regulation 355/90. These emission levels were approximately 60% and 54% below the limits set for 1993 and

39% and 37% below the 1994 regulated limits. Detailed SO_2 and NO emission audits were conducted semi-annually for 1993 and 1994. Hydro updated the NO vs. load curves for all remaining operating units before December 1994 as required by the Order.

Highlights of the Auditor's Report:

Annual SO_2 and total acid gas (SO_2 and NO) emission audits were conducted for each of the fossil-fuelled generating plants for 1993 and 1994. Diesel generator facilities serving remote communities and standby gas combustion turbines at fossil-fuelled and nuclear generating plants were also audited in 1993 and 1994. The auditor confirmed that ≥ 99 % of SO_2 and ≥ 95 % of NO emissions in 1993 and 1994 resulted from coal fuel combustion for electricity generation. The uncertainty for the semi-annual SO_2, NO, and total acid gas emissions for 1993 and 1994 ranged from 2.9% to ±4.8 %, 7.1% to ±9.1 % and 2.7% to ±4.1%, respectively.

The auditor verified that the SO_2 and total acid gas emissions in 1993 and 1994 were calculated according to the procedures described in the manual. No major deviations from these procedures were noted. In addition, the accuracy of SO_2 and NO emission estimates were statistically evaluated for reliability. Minor bias errors were found in inter-laboratory comparisons for sulphur analysis at the Lakeview, Nanticoke and Thunder Bay stations.

Fly ash analysis performed and reported in the fourth quarter of the 1992 AEL audit report indicated that sulphur retention values differ significantly from the default values used in the acid gas emission estimates. No updates to fly ash retention were done in 1993 and some values used in the 1994 SO_2 emission estimates were based on 1989 analysis values.

The 1992 ultimate coal analyses used to develop default flue gas volumes for estimating 1993 NO emissions, did not reveal any bias errors. Data handling and calculation errors were the main discrepancies noticed in semi-annual audits. There is no system in place for tracking emission data corrections or other adjustments made.

The auditor recommended the following:

- ensure all station laboratories use ASTM standards when performing coal sulphur analysis.

- conduct regular annual fly ash analysis for calculating the actual sulphur retention factor.
- update the reporting system and emission estimating procedures to reduce manual data handling when the mass balance method is to be used as the primary or backup method.

4. **Overall Comments on Acid Gas Emissions Audits**

Since establishing the audit program in 1990, the major acid gas emitters have improved the accuracy and reliability of the reported annual emissions, and standardized their emissions estimating procedures. The third party independent audits of emission levels provide acceptance and credibility for reported emissions.

Reporting accurate SO_2 and NO emissions levels is also important to ensure that the Provincial Government Auditor's requirements and Federal/Provincial agreements are being met. In addition auditing programs are required to substantiate acid gas emissions since stricter annual emission limits may be imposed in the future.

The Ministry is also maintaining the option of requiring continuous emissions monitoring (CEM) systems for all major emitters of SO_2 and NO in Ontario.

5. **Recommendations**

1. It is recommended that the annual independent audit program for the four major emitters of SO_2 and acid gases (SO_2 and NO) as required by the Director's Orders be continued.

6. **SOURCES OF INFORMATION**

1. Government Review of the Countdown Companies Acid Gas Emissions Audit (1991)
2. INCO Limited - Ontario Division: SO_2 Emission Procedural Audit Report for the year ended December 1993 by Price Waterhouse (1994).
3. INCO Limited - Ontario Division: SO_2 Emissions Procedural Audit Report for the year ended in December 1994 by Price Waterhouse (1995).
4. Audit of Reported SO_2 Emissions from the Falconbridge

Smelter for 1993 by Hatch Associates Ltd. (1994).

5. Audit of Reported SO_2 Emissions from the Falconbridge Smelter for 1994 by Hatch Associates (1995).

6. Audit of Annual SO_2 Emissions for the year 1993 for Algoma Steel Inc. Ore Division (Wawa, Ontario) by Rowswell And Associates Engineers Ltd.(1994).

7. Audit of Annual SO_2 Emissions for the year 1994 for Algoma Steel Inc. Ore Division (WAWA, Ontario) by DNE Knight Piésold Consulting Engineers(1995).

8. Procedural Audit of Ontario Hydro's Measurement Methodology for Acid Gas Emission Estimates for Fourth Quarter 1993 and for 1993 annual emissions by Angus Environmental Ltd. (April 1994).

9. Procedural Audit of Ontario Hydro's Measurement Methodology for Acid Gas Emission Estimates for second half of 1994 and for 1994 annual emissions by Angus Environmental Ltd.(May 1995).

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